ELECTRICAL MACHINE CONDITION MONITORING AND FAULT DIAGNOSTICS

EE72504

Lecture : 3 **Year : IV**
Tutorial : 1 **Part : I**
Practical : 3/2

Course Objectives:
To develop a comprehensive understanding of the principles and application of condition monitoring in anomaly detection and fault diagnosis of electrical machines and to understand the behavior of normal and faulty machines through computer-based fault simulation technique.

1 Overview of Electrical Machines (3 hours)

1.1 Application of electrical machines in industries and utilities such as processing industry, power plants, transports etc
1.2 Consequences of equipment failures
1.3 Techniques to avoid failure of machines
1.4 Breakdown versus condition-based-maintenance

2 Introduction to condition monitoring (4 hours)

2.1 Condition monitoring overview and purpose
2.2 Common condition monitoring techniques
2.3 Invasive and non- invasive methods
2.4 Sensors, data acquisition and overview of signal pre- processing for condition monitoring

3 Faults in Transformers and Diagnosis (16 hours)

3.1 Review of Transformer construction and operation, Behavior of normal Transformer, Transformer condition indicators
3.2 Insulation classes, Cooling system
3.3 Thermal performance of Transformers: heating at constant load, heating under variable load, insulation wear and load capacity, overload
3.4 Transformer faults: main causes, core faults, winding faults, switching failures, tank fault, other failures
3.5 Transformer testing and fault diagnostics: HVPD tests, Acoustic detection, short- circuit and open- circuit impedance measurement, frequency response analysis, polarization index, measurement of DC resistance, tan-delta tests, Dissolved Gas analysis
3.6 Fault simulation exercise and laboratory demonstration

4 Faults in Rotating Machines and Diagnosis (22 hours)

4.1 Review of machine construction and operation, Behavior of Normal Machines, Machine condition indicators

4.2 Electrical faults: Symmetrical faults, Asymmetrical faults, Unbalance supply voltage, Over voltage, Phase reversal, Overload stator short circuit, Broken rotor bars and End- ring faults

4.3 Mechanical faults

4.4 Airgap Eccentricity: Static, Elliptical, Dynamic and Mixed Eccentricity, Bearings damage

4.5 Machine testing and Fault Diagnostics: Fault indicators and Fault Representing Equations

4.6 Bearing currents and its diagnosis: indirect methods: vibration, ultrasonic detection and direct methods: voltage measurement, Rogowski coil, reduction of bearing currents: insulated bearing, conductive greases, shaft grounding contacts and rings, characteristics regulation of frequency converters

4.7 Diagnostics of stator and rotor faults: power electronics, local and global sizes, how the faults start, methods of diagnostics: side harmonics, magnetic flux density distribution, park- Clarke vector, winding control, insulation, measurement of insulation resistance

4.8 Fault simulation exercise and laboratory demonstration

5 Condition Monitoring and Condition Based Maintenance (15 hours)

5.1 Types of maintenance: Breakdown vs. Condition based maintenance: scheduled, preventive and predictive maintenance

5.2 Condition monitoring and signal processing for state of health and fault indications

5.3 Recent trend in Condition based maintenance: Remote sensing and Cloud based monitoring and maintenance management: internet of things (IOT), IOT based sensing

5.4 Application of Machine learning and Artificial Intelligence for Maintenance, Use of trained models for anomaly detection and fault diagnosis

5.5 Commercial CMMS (Cloud/Computer based maintenance management system), CMMS Architecture and interface, Use of CMMS

Practical:

1. Simulation of common motor faults like eccentricity and stator winding fault and motor current signature analysis
2. Thermal analysis of machines for healthy and faulty cases
3. Demonstration of Soft-foot fault and vibration and current signature analysis

4. To check overheating of windings or the transformer core through temperature monitoring.
5. To measure and monitor the stator current of 3 phase induction motor using current sensors to identify abnormalities such as unbalanced phases or overloading.
6. To analyze harmonic content in the current waveform to detect faults like rotor bar defects or air-gap eccentricity of 3 phase rotating machine

Evaluation Schemes

a. Internal Examination (20%)

Type	Weightage
Minor tests	**40%**
Assignments	**20%**
Attendance	**20%**
Class participation and presentation	**20%**

Final Exam (80%)

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks Distribution*
1	3	6
2	4	6
3	16	20
4	22	28
5	15	20
Total		**80**

* There may be minor deviation in marks distribution.

References

1. Rao, B. K. N. (1996). *Handbook of condition monitoring*. Elsevier Science.
2. Sen, P. C. (n.d.). *Principles of electrical machines and power electronics* (2nd ed.). John Wiley & Sons.
3. Course handouts/manuals.
4. Latest publications on the related topics.